# Biological Considerations in National Standard 1

## Limits Based on MSY

Sustainable fisheries rely upon the tendency of harvested populations to have a higher per-capita productivity than unharvested populations. This higher per-capita productivity occurs as low to moderate levels of fishing mortality (***F***) reduce the abundance (***B***iomass) of a fish stock and the average age of fish in the stock. The productive tendency to grow back to the stock's unfished level of abundance is the source of a sustainable harvest. The level of ***F*** is basically the slope of the Control Rule lines in Figures 1 and 2. The Control Rule provides numeric guidance for adjusting annual catch targets and limits to track forecasts of fluctuations in stock abundance and achieve the fishery's optimum yield on an ongoing basis. The blue curve in Figure 1 is the relationship between average catch and average biomass for ***F*** values ranging from 0 on the right (unfished) to very high levels on the left (overfishing). Under prevailing ecological and fishery conditions, there is a level of ***F*** (MSY control rule) that would produce the maximum long-term average yield (MSY - red circle in Figure 1). The NS1 Guidelines set this as the upper limit ($F_{lim}$) for the annual ***F***. Fishing at a rate above $F_{lim}$ is overfishing because it jeopardizes the capacity of the stock to produce MSY. While fishing at the MSY control rule, the abundance of the stock (biomass) will tend to naturally fluctuate around the $B_{msy}$ level, which is typically near 30-50% of the unfished level of abundance. Stocks that fall below $B_{lim}$ (typically set at ½ $B_{msy}$) are considered depleted (red shaded zone in Figure 2). This can occur due to a combination of overfishing and extreme natural fluctuations in productivity.

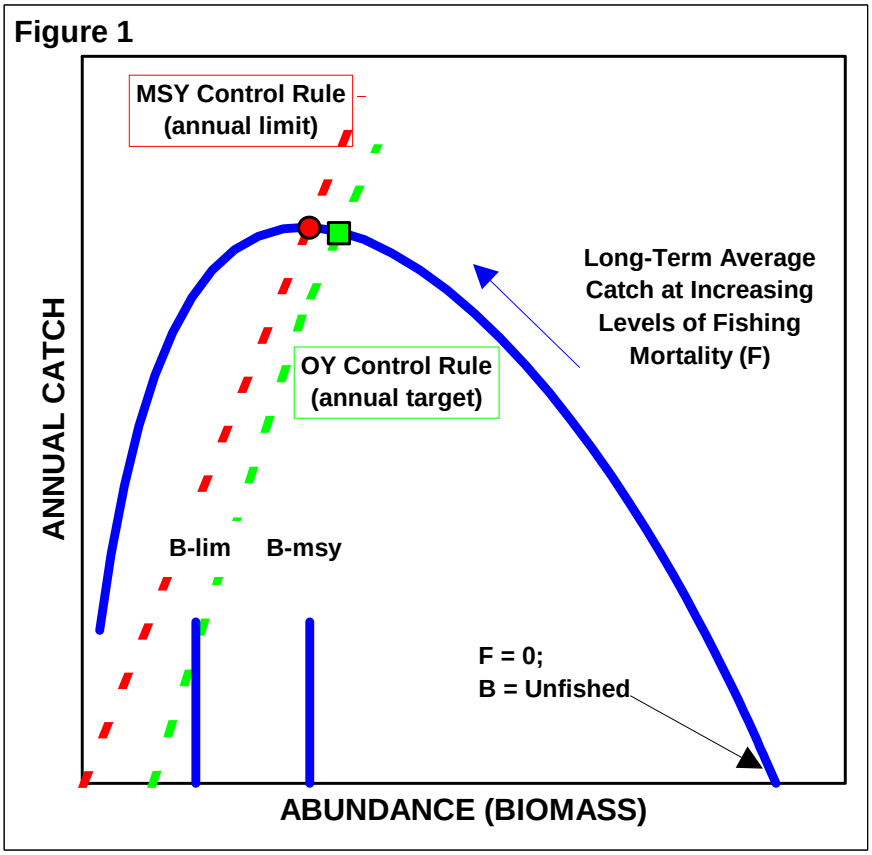
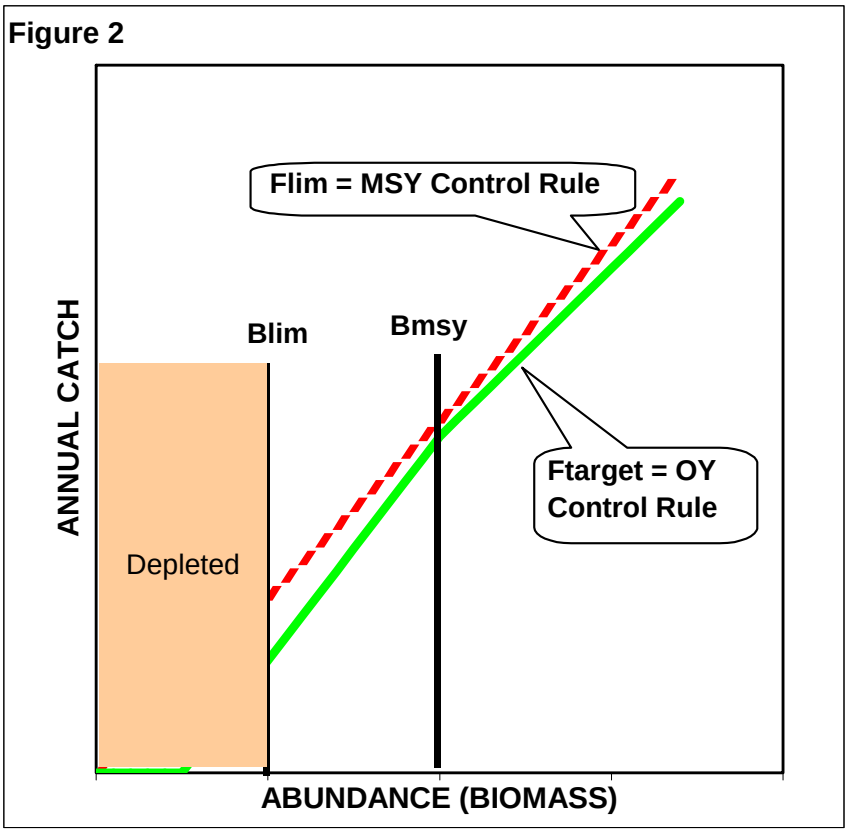


Figure 2




**Preventing Overfishing**

Depleted stocks cannot produce optimum yield (OY - green square in Figure 1) on an ongoing basis, and also raise concerns about ecosystem harm . The OY Control Rule is the $F_{target}$. It is set below $F_{lim}$ in order to:

- provide at least a 50% chance that actual $F$ will be below the limit and;
- reduce the chance that a string of years with poor productivity, inadequate fishing controls, or assessment uncertainty will cause the stock to fall below $B_{lim}$.

In the Figure 1 example, $F_{target}$ is set at 90% of $F_{lim}$ when $B$ is above $B_{msy}$. Even though the annual target catch is 10% less than the catch limit for a given level of abundance, the larger mean abundance that results from this lower $F$ means that long-term average OY is only 1% less than MSY. A greater buffer between $F_{target}$ and $F_{lim}$ at lower stock biomass levels helps prevent declines below $B_{lim}$. In cases where there is insufficient technical information to calculate these various quantities, the OY targets should still be designed to provide a buffer against overfishing.

## Rebuilding Depleted Stocks

If a stock is depleted, a rebuilding plan must be implemented to rebuild the stock to $B_{msy}$ in as short a time as possible, subject to various considerations including the needs of the fishing community, international agreements and the biology of the stock. The rebuilding plan is a temporary modification of the OY control rule in order to rebuild the stock to the level that can once again produce OY on an ongoing basis. The target time to rebuild is bounded by $T_{min}$ and $T_{max}$, where $T_{min}$ is the year in which there is a 50% probability of being rebuilt if there was no fishing (Figure 3). The $T_{min}$ calculation depends upon future productivity that cannot be known exactly, so there is a probability distribution on $T_{min}$. This distribution can be calculated accurately from stock assessments, even if the exact year of rebuilding cannot be forecasted. The current NS1 Guidelines set $T_{max}$ as the lesser of 10 years or $T_{min}$ plus one generation time (Figure 3). The generation time is calculated as the mean age of reproductive fish in the population and provides an index of the turnover rate of the population. The example in Figures 3 and 4 has generation time equal to 5 years. The resulting discontinuity in the rebuilding time frame at 10 years is problematic, especially given the inherent uncertainty in $T_{min}$. The proposed revision to the NS1 Guidelines would smooth this transition by setting $T_{max}$ at the greater of 10 years or $T_{min}$ plus one generation time, and would set a recommended default $T_{target}$ that is midway between $T_{min}$ and $T_{max}$.